

Thrombolysis Delivery by a Regional Telestroke Network—Experience From the UK National Health Service

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Background—The majority of established telestroke services are based on “hub-and-spoke” models for providing acute clinical assessment and thrombolysis. We report results from the first year of the successful implementation of a locally based telemedicine network, without the need of 1 or more hub hospitals, across a largely rural landscape.

Methods and Results—Following a successful pilot phase that demonstrated safety and feasibility, the East of England telestroke project was rolled out across 7 regional hospitals, covering an area of 7500 square miles and a population of 5.6 million to enable out-of-hours access to thrombolysis. Between November 2010 and November 2011, 142 telemedicine consultations were recorded out-of-hours. Seventy-four (52.11%) cases received thrombolysis. Median (IQR) onset-to-needle and door-to-needle times were 169 (141.5 to 201.5) minutes and 94 (72 to 113.5) minutes, respectively. Symptomatic hemorrhage rate was 7.3% and stroke mimic rate was 10.6%.

Conclusions—We demonstrate the safety and effectiveness of a horizontal networking approach for stroke telemedicine, which may be applicable to areas where traditional “hub-and-spoke” models may not be geographically feasible. (*J Am Heart Assoc.* 2014;3:e000408 doi: 10.1161/JAHA.113.000408)

Key Words: NHS • telestroke • thrombolysis

Telestroke is becoming a widespread and fast growing practice model for increasing access to thrombolysis. The European Stroke Organisation¹ and the American Heart Association/American Stroke Association² have both issued guidelines encouraging the formation of telestroke networks and development of teleconsultation services. Most current academic medical center-based telestroke programs are based on variations of the “hub-and-spoke”^{3,4} model, whereby

1 or more regional centers provide expertise via a telecommunication link to peripheral centers. These models may be challenging to implement in largely rural landscapes, where transport links to regional centers present difficulties.

The East of England is a large, predominantly rural region covering 7500 square miles, a population of 5.6 million people, and approximately 6000 stroke patients, annually. Prior to the current telemedicine set up in November 2010, there were 2 regional centers providing thrombolysis 7 days a week, 24 hours a day. Projected ambulance travel time of 45 to 60 minutes from peripheral centers to either one of these 2 regional centers ruled out a 2-hub model of telestroke in our region. This motivated horizontal organization of the program, which was rolled out following successful completion of a pilot project between September 2009 and January 2010.

Figures from the Department of Health, UK suggest that ≤5% of stroke patients are thrombolized on average across the country.⁵ In our region alone, by increasing the thrombolysis rates to an average of 10%, the estimated cost savings to the National Health Service (NHS) would be nearly £2.7 million, by preventing long-term disability. Based on figures from the European Safe Implementation of Treatments in Stroke (SITS) database⁶ for our region for 2009–2010, 382 stroke patients received thrombolysis for stroke. Thus, for an

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average annual load of 6000 cases, average overall thrombolysis rates are $\approx 6.36\%$ across the region.

Methods

Organization of the Network

The East of England telestroke project is hosted jointly by the Cambridge University Hospitals NHS Foundation Trust and the regional Strategic Health Authority. The program runs across 7 hospitals (Figure), namely, Ipswich Hospital, James Paget University Hospital, Lister Hospital, Peterborough Hospital, Queen Elizabeth Hospital, Watford General Hospital, and West Suffolk Hospital. All these hospitals are classified as district general hospitals with an inpatient capacity of approximately 500 beds. Detailed bed size figures and annual emergency attendance numbers, as obtained from the NHS Information Centre for Health and Social Care,⁷ are outlined in the figure. Each of these hospitals runs their own thrombolysis rotas during working hours with on-site stroke specialists. The main objective of the telemedicine service is to provide real-time, out-of-hours access to thrombolysis, ie, evenings (17:00 to 08:00), weekends and bank holidays. A regional rota of 10 stroke specialists from across the sites has been created to deliver the service. All participating specialists had attended

regional thrombolysis training days, had access to case discussions in peer-review format via regional videoconferencing meetings and were registered users for the European Safe Implementation of Treatments in Stroke (SITS) database. Thrombolysis was administered as per standard clinical guidelines and the time window for thrombolysis was 0 to 4.5 hours. Definition of symptomatic intracranial haemorrhage (sICH) was the same as that from the NINDS trial, ie, any deterioration in neurological status accompanied by intracranial haemorrhage.^{8,9}

Technology and Process

The telemedicine cart, provided to the emergency departments of participating hospitals, is comprised of a PC in a bespoke mobile trolley (Parity Medical[®]) with an additional high-resolution CCTV camera mounted on top of the screen. Each consultant has access to a 17" laptop coupled to the telemedicine cart using Visimeet[®] videoconferencing software, allowing rapid access to the virtual consultation "room" accessed by a wired/less connection to a dedicated server on a secure NHS (N3) network. The clinical team at the participating hospital can view and speak to the remote telestroke consultant via the cart, using the camera that can be controlled from both sides.

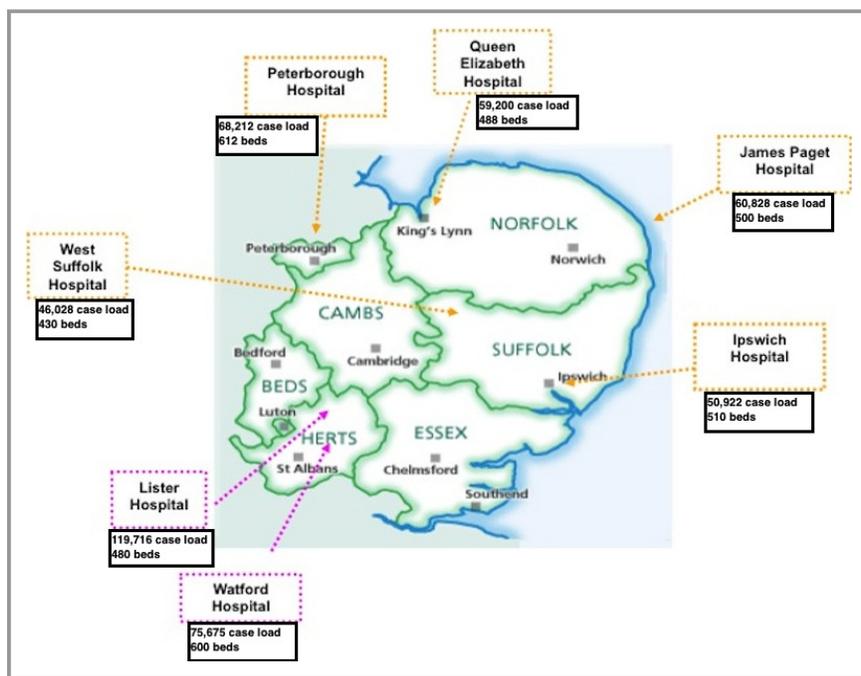


Figure. Geographical organization of the East of England telestroke network. As per data from National Health Service (NHS) Information Centre for Health and Social Care, annual overall emergency attendances (case load for all emergency cases, *not* stroke alone) and hospital bed size for each of the participating sites is shown for 2009–2010, except for Lister Hospital for which these figures were not available and thus 2012–2013 figures have been mentioned.

Approvals

The telemedicine project was reviewed and approved by the institutional review boards at the individual hospitals and the Strategic Health Authority for administration of thrombolysis via standard clinical guidelines.¹ Verbal consent was obtained from the patient or next of kin prior to telemedicine consultation.

The project was registered with the institutional review boards at each site for prospective audit data collection, for the pilot phase, and subsequently for the first year of service roll-out. Anonymized clinical information was retrieved from prospectively recorded audit data.

Statistical Analysis

All data were analyzed using IBM SPSS 19[®] for Mac. Mean values with standard deviations (SD) and median values with interquartile ranges (IQR) are reported here with comparisons between patients in “thrombolysis” and “no thrombolysis” groups, using 2-sample *t* tests and Wilcoxon rank sum test where appropriate, alongside 2-sided *P* values.

Results

For safety and feasibility assessment, a pilot phase was run between September 2009 and January 2010 across 4 regional hospitals. Forty-three telestroke consultations were recorded leading to 15 patients receiving thrombolysis. Mean (range) consultation length was 30 (10 to 70) minutes for the cases that received treatment versus 18 (2 to 55) minutes for the others. Mean age of patients was 72 years (range 54 to 88), median NIHSS 13, mean door-to-needle time 56 minutes,

mean onset-to-needle time 131 minutes and there were no symptomatic hemorrhages; asymptomatic hemorrhage rate was 13.3%.

Following on from the successful pilot phase, 164 consultations were recorded between November 2010 and November 2011. Clinical data were incomplete for 22 cases; hence, 142 cases (Table 1) are included in this report. Overall, 74 patients received thrombolysis. Mean (SD) age of “thrombolysis” group was 69.4 (14.3) years; for “no thrombolysis” group, 65.7 (16) years. Median NIHSS was higher (10 versus 5, *P*=0.006) in the “thrombolysis” group. Median door-to-scan time was comparable (*P*=0.748) between the 2 groups. For the “thrombolysis” group, median (IQR) door-to-needle time was 94 (72 to 113.5) minutes and median (IQR) onset-to-needle time was 169 (141.5 to 201.5) minutes.

Among the 68 cases that did not receive thrombolysis, 18 were stroke mimics including migraine, seizures, and functional illness. Reasons for not treating patients with a final diagnosis of stroke included uncertain time of onset (*n*=7), severe stroke with comorbidities and high hemorrhage risk (*n*=4), low NIHSS at presentation and/or improving neurological deficit at the time of assessment (*n*=23), ≥ 1 recognized contraindications for thrombolysis (*n*=10),¹ hemorrhage on initial CT (*n*=6), age with comorbidities (*n*=1, age=93 years). In 2 cases, the reason for not administering treatment was unclear from the available data.

We also provide a comparison of our performance against figures from major published telestroke series across the world (Table 2).

Quarterly audit figures for thrombolysis rates prior to and post commencement of telemedicine are available for 5 of the 7 hospitals (Table 3). Note that the pre-telemedicine figures

Table 1. Baseline Characteristics of Patients in the Telestroke Cohort

	Thrombolysis (N=74)	No Thrombolysis (N=68)	<i>P</i> Value
Age (y), mean (SD)	69.4 (14.3)	65.7 (16)	0.15
Male:female	53:21	35:33	0.02
NIHSS, median (IQR)	10 (5.75 to 15.25)	5 (3 to 12.5)	0.01
Onset to needle (min), median (IQR)	169 (141.5 to 201.5)	n/a	n/a
Door to needle (min), median (IQR)	94 (72 to 113.5)	n/a	n/a
Door to scan (min), median (IQR)	29.5 (22.5 to 55)	40 (26 to 51)	0.75
Hemorrhage rate (NINDS) ^b	7.3%	n/a	n/a
In hospital mortality	8.1%	7.4%	0.78
Call duration (min), mean (SD)	32.9 (15.1)	26.9 (42.2)	0.40

Mean call duration available for 89 cases overall; *n*=50 thrombolysed cases and *n*=39 for cases not thrombolysed. Five cases of unknown onset time, none received thrombolysis. Follow-up scans unavailable in 9 cases that were thrombolysed, sICH rates 5/69=7.3%. IQR indicates interquartile ranges; NINDS, National Institute of Neurological Disorders and Stroke; NIHSS, National Institutes of Health Stroke Scale.

Table 2. Comparison of Thrombolysis Figures From Representative Published Telestroke Programs Around the World and the East of England (EoE) Project

	TEMPiS ¹⁰	REACH ¹¹	STRokE DOC ¹²	Finnish Telestroke ¹³	EoE Telestroke	Pilot Results	NINDS Trial ⁸
Area	Regional	Regional	Regional	National	Regional	Regional	
Hub/spoke	2/12	1/8	1/4	1/5	n/a	n/a	n/a
Thrombolysis n	106	30	31/25*	61	74	15	
Mean age, y	68	62	70.4/69*	61	69	72	67
Median NIHSS score	12	11.5	12.7/9.8*†	10	10	13	14
Mean onset to needle time, min	141	122	157.2/143.2*	130	170.1	131	Not reported
Mean door to needle time, min	76	104.9	Not reported	24	94.9	56	Not reported
Hemorrhage rate%	8.5	0	7/8*	6.7	7.3	0	6.4
In hospital mortality%	10.4	7	Not reported	9.8	8.1	Not reported	Not reported

n/a not applicable.

*Telemedicine/telephone only consultations.

†Mean NIHSS described in these studies.

Table 3. Quarterly Thrombolysis Figures From Audit Data Prior to and After Roll out of the Telemedicine Service

Hospital	Pre Telemedicine Thrombolysis Rate (%)	Post Telemedicine Thrombolysis Rate (%)
West Suffolk Hospital	1	12
Peterborough Hospital	6	7
Queen Elizabeth Hospital	4	13
James Paget Hospital	5	14
Ipswich Hospital	4	9

Note that these figures were not available for 2 of the 7 hospitals, namely Lister Hospital and Watford Hospital. Pre thrombolysis rates represent daytime activity whereas post telemedicine rates, when the thrombolysis service became 24×7, are overall rates including daytime and out-of-hours work.

represent daytime thrombolysis activity as these hospitals did not have an out-of-hours service before telemedicine was set up.

Discussion

Our series demonstrates that a locally based model for telestroke consultations is deliverable and safe. The novelty of this structure is that local stroke physicians participate in the regional service; thus delivery is not dependent on regional centers. This has advantages for local specialists in that they retain competencies in treating sufficient numbers of thrombolysis cases, even though their own services are relatively small; while more effectively sharing the burden of overnight call for low-frequency, high-impact events. Also, it has potential logistic advantages in organizing follow-up care. This *hubless* model of organization of our telestroke network

is what distinguishes it from the majority of other successfully running telestroke services across the world.^{3,4} Keeping services local has particular advantages in relatively large rural landscapes by minimizing dependence on regional transport services and developing rehabilitation and follow-up care for patients closer to where they live.

Our figures compare well with published telemedicine series, apart from slightly longer door-to-needle and onset-to-needle time, which may partly be a reflection of our geographical location and transport challenges.^{2,3} While our door to scan times are comparable to published UK-wide time metrics from the SITS database for a similar time period (Median onset-to-needle=150 minutes, door-to-needle=65 minutes, door-to-scan=31 minutes)¹⁴ and the Stroke Improvement National Audit Programme published by the Royal College of Physicians, UK¹⁵ (Median door-to-needle=60 minutes, door-to-scan=32 minutes), our door-to-needle and onset-to-needle times could be improved further. Attempts, such as involvement of on-site specialist nurses, are underway for further improvement. However, the differences need to be interpreted in light of the fact that the telemedicine service runs for out-of-hours only and direct comparisons or out-of-hours figures are not available for each site or separately from national audit figures.

Our teleconsultation thrombolysis rate (52.1%) approaches the highest figure reported to date, from the Finnish telestroke network (57.5%)¹³ and compares well with earlier models such as TEMPiS (29.8%)¹⁰ and REACH (15.5%).¹¹ The high rate of thrombolysis may suggest that the service may be currently underutilized. Besides, the number of overall consultations in the first year of service roll out is smaller than some of the well-established telestroke projects like TEMPiS.¹⁶ Thus, our model has potential for a greater impact on thrombolysis delivery with further establishment of its role. As outlined earlier, average overall thrombolysis rate in our

region is around 6%. Table 3 shows an increase in thrombolysis activity for the hospitals, where quarterly audit data for overall thrombolysis rates were available before and after commencing telemedicine.

Symptomatic hemorrhage rate of 7.3% is at par with other series and early trial data (Table 2). Also, noteworthy is that no cases of in-hospital mortality occurred due to hemorrhage, indicating safety of the approach.

Mean call duration data (available for n=89 cases; Table 1) did not differ between the 2 groups ($P=0.395$). Median NIHSS was lower, as expected, in the “no thrombolysis” group, with presence of stroke mimics and cases with improving neurological deficits.

It would be interesting to examine whether there is meaningful variability in how well the network works for different hospitals and whether the success depends on local expertise and/or varying patient populations. While Table 3 highlights this variability, the sample size for the project data is too small to examine such factors for each site individually. Further long-term data would be needed to investigate these systematically.

One of the limitations in our data is the unavailability of long-term clinical outcomes. Currently, the project is successfully running across 14 hospitals, from which further clinical data collection is in progress. Also, cost savings and resource implications merit further assessment.

Conclusion

In summary, the East of England telestroke project has demonstrated safe and efficacious delivery of an out-of-hours thrombolysis service across regional hospitals in a large rural landscape.

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Disclosures

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